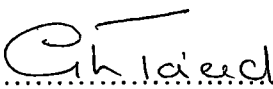


# **The relationship between attention and achievement in reading and numeracy**

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I declare that this thesis is my own work and that, to the best of my knowledge and belief, it does not contain material from published sources without proper acknowledgement, nor does it contain material which has been accepted for the award of any other higher degree or graduate diploma in any university.

Signed .....  .....

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## **Literature Review**

The relationship between attention and achievement in reading and numeracy

## Abstract

The well established link between behavioural problems and academic underachievement (Hinshaw, 1992) has resulted in research aimed at identifying which type of behavioural difficulties are correlates of underachievement. Inattention has consistently been shown to be a major factor in reading difficulties as well as being linked to poor performance in other academic areas. This suggests that investigations of children's achievement may benefit from including an assessment of their attentional abilities aimed at identifying the kinds of attentional problems that are associated with underachievement. This review considers some of the difficulties of defining attention and outlines some approaches to its measurement. The broad consensus among researchers is that attention is not a single cognitive function. Aspects of attention that have received the greatest research and clinical interest are selective attention, sustained attention, divided attention and attentional switching. The main approaches to assessing attention are rating scales, generally by teachers or parents, and cognitive tests, which raise different issues of validity. Studies are needed to compare these different assessment methods and to see which methods best assess different aspects of attention. Future research could also look at sex differences in attentional abilities and their relationship to different patterns of achievement in boys and girls across subject areas.

## *Introduction*

It is well established that children who experience difficulty learning to read are at risk for poor social, emotional and behavioural outcomes (Hinshaw, 1992).

Researchers over many decades have attempted to identify factors that relate to reading problems with a view to identifying possible causal mechanisms and implementing both preventative and remedial strategies. Factors such as economic and social status; intelligence; reading activity in the home; temperament including co-operation, manageability, irritability and impulsivity; maternal education; fathers' occupation; school readiness; and behaviour problems have all been investigated in this context.

Inattention has been shown to be a major factor in reading disability and has also been related to poor performance in other academic areas. This review is directed towards the assessment of attention and its role in achievement in reading and numeracy.

## *Word Recognition and Comprehension*

Investigations of the correlates of reading disability are based on research into the mechanics of word recognition and comprehension which underlie the ability to read fluently. Early researchers attempted to identify whether words are recognised on a visual basis or by phonological coding. Using visual information would seem more efficient because it involves a direct process from orthography to meaning. Using phonology, on the other hand, adds an extra step from orthography to phonology to meaning. However a large body of research (for example Hatcher & Hulme, 1999; Share, 1995; Wagner & Torgesen, 1987) indicates a role for phonological abilities in the development of a child's reading skills.



Phonological abilities is a broad term used to encompass a number of phonological skills associated with oral language, such as awareness of rhyme and alliteration as well as skills associated with phonemic awareness. Early phonological ability appears to develop naturally and independently of reading instruction in children who are exposed to sound games such as nursery rhymes. Phonemic awareness is a more specific term which refers to “one’s awareness of and access to the abstract sound structure of one’s language” (Mattingly, 1972). Children demonstrate phonemic awareness when they can separate a word into its phonemes: for example the word “cat” into the three phonemes /k/ /ae/ /t/, or if the phonemes are presented separately they can blend them into the word “cat”. Children with poor phonemic awareness are likely to become poor readers (Bradley & Bryant, 1983) and instruction that focuses on phonemic awareness, particularly if it teaches children to link letters with sounds, has been shown in numerous studies (Byrne & Fielding-Barns, 1991; Bus, & van IJzendoorn, 1999; Ehri et al. 2001), to facilitate early reading skills. Letter-sound knowledge and phonemic awareness are critical co-requisites in reading acquisition (Share, 1995) and measures of phonemic awareness are powerful longitudinal predictors of later reading skills (Hulme et al., 2002).

One barrier to the use of phonological abilities in reading English is the large number of words that deviate from orthographic-phonological correspondence rules that it contains. These are usually known as irregular words. Most words can be pronounced “by rule” but irregular words deviate from the rules in varying degrees from words such as pint with small deviations, to words such as yacht and colonel which have a wide discrepancy. In order to account for how such words are read Coltheart and his associates (Coltheart, 1978; Coltheart, Curtis, Atkins & Haller, 1993) have proposed “dual route” models in which two alternative routes are used in

word recognition: a direct and an indirect route. The direct or lexical route is used for words that are already familiar to the reader who retrieves the words and their pronunciation from an internal lexicon. The indirect route enables the reader to read regular words that they have never encountered before and to pronounce non-word letter strings using orthographic-phonological correspondence rules. Irregular words can not be processed through the indirect route and have to be learned individually and stored in the internal lexicon.

### *Assessment of Reading*

The central goal of reading is to extract meaning from a text. Methods of assessing reading which emphasise comprehension may therefore seem the best way of measuring how well someone can read. However poor performance on a comprehension task does not necessarily reflect poor ability to read because other factors such as understanding of the material, memory and ability to answer questions, may interfere with the assessment. One way of overcoming this is to use a measurement of discrepancy between listening and reading comprehension which has been suggested to provide a specific estimate of reading disability (Badian, 1999) because it distinguishes between reading and the other cognitive processes involved in the task.

Another assessment method is written word pronunciation which is claimed (Zinar, 2000) to be a good measure of reading with less reliance on verbal ability than comprehension tests. This is tested with a printed list of words which are often ordered by difficulty. For alphabetic languages, such as English, word reading relies heavily on the acquisition and application of phonological skills and knowledge (Adams, 1990; Garton & Pratt, 1998). The application of knowledge of letter-sound correspondences is referred to by some authors as phonological recoding (for example Share, 1995) and by others as phonological decoding (for example Snowling, Hulme

& Goulandris, 1994) and may be tested using a nonword reading test (for example the Martin and Pratt Nonword Reading Test; Martin & Pratt, 2001). While regular words may be decoded phonologically, the correct pronunciation of irregular words must be experienced and stored. Irregular word reading is assumed to depend on children's exposure to print and the extent to which they read books (Cunningham & Stanovich, 1990) and may be tested using an irregular word test (for example the 30-item list of irregular words published in Coltheart and Leahy, 1996).

### *Sex Differences in Reading*

Early research in reading development showed sex differences in reading performance (Thompson, 1975) with boys over-represented at the lower end of the distribution compared to girls. This has been confirmed by numerous studies with the ratio of boys to girls diagnosed with reading disability varying according to the definition of disability employed.

Rutter and Yule (1975) divided below-average reading achievement into two categories, reading achievement significantly behind the level expected for the child's age (termed general reading backwardness or GRB) and reading achievement significantly behind the level predicted from intelligence as well as age (termed specific reading retardation or SRR). GRB children usually display below average intellectual performance, particularly in the verbal domain, whereas children with SRR typically have average or above-average IQ scores. Rutter and Yule found that compared with GRB children, SRR children were overwhelmingly boys, and although SRR children displayed a somewhat better outcome in arithmetic than GRB children they had a far worse prognosis in reading and spelling.

A more recent investigation (Alexander & Martin, 2000) found that females average about two points higher on tests of basic reading skills but this is due to a

male disadvantage at the bottom end of the distribution, not at the top where there appears to be no difference between boys and girls, reflecting the greater variability of males.

### *Reading Disability*

A number of researchers (Critchley, 1970; Miles & Haslum, 1986) maintain that some sort of pathology, usually referred to as developmental dyslexia, underlies reading disability. Dyslexia refers to a clinical syndrome for poor reading in relation to intelligence but includes other symptoms such as left/right uncertainty and difficulties with sequencing. Acquired dyslexia refers to a reading disability acquired after childhood: usually as a result of brain injury. Developmental dyslexia is a reading disability that occurs in childhood. Miles, Haslum and Wheeler (1998) found a smaller number (2.3%) of their sample of 11,804 ten-year olds met the criterion of strictly defined specific developmental dyslexia than the more general criterion of poor reading in relationship to intelligence (4.2%) but the proportion of males to females was higher in the specific developmental dyslexia group (81% males; 19% females) than in the poor reading in relationship to intelligence sample (62% males; 38% females).

Other investigators (Shaywitz, Escobar, Shaywiz & Fletcher, 1992; Stanovich, 1988) suggest that reading ability has a normal distribution with the reading disabled falling on the lower part of it. Stanovich argues that the concept of dyslexia is the outcome of the application of an arbitrary criterion on this continuous distribution. This implies that the same factors that are involved in making some children good readers will make other children poor readers. Moderate correlations between reading and intelligence show many poor readers have low intelligence or low verbal ability

and suggest a distinction between poor readers with low verbal ability and specific reading disability.

One hypothesis put forward to explain reading disabilities is the developmental lag or delay hypothesis which suggests that children who are poor readers learn reading skills in the same way as good readers but they do so at a slower rate (Rack, Snowling & Olson, 1992; Stanovich, 1988). This has led some researchers (for example Shaywitz, Fletcher & Shaywitz, 1995) to suggest that the poorer performance in reading of boys compared to girls is the result of a slower rate of maturation or a male developmental delay.

#### *Sex Differences in Numeracy*

If a male developmental delay is responsible for the overrepresentation of boys in the lower end of the distribution of reading ability it might be expected that they would be disadvantaged in all academic subjects. However this is not the case in numeracy. Population studies, for example, show comparable figures for boys and girls in numeracy. In 2001, 6.3% of Grade 3 boys failed to achieve the Australian benchmark for numeracy compared with 5.7% of girls (Ministerial Council on Education, Employment, Training and Youth Affairs, 2001). This is much less than the figures for reading. In 2001, 12.2% of Grade 3 boys did not achieve the Australian benchmark for reading compared with 8% of girls.

Studies have indicated that in some aspects of numeracy boys perform better than girls. For example Manger (1995) investigated the relationship between sex and mathematical achievement in Norwegian third graders (440 girls and 484 boys). Children completed a 100-item mathematical-achievement test and it was found that boys had higher total test scores than girls, but the effect size was small. Boys performed better than girls in numeracy problems, mental arithmetic and measurement

problems. Marked differences were found at the extreme tails of the distribution.

Among the 10% highest on numeracy problems there were nearly twice as many boys as girls. Among the lowest 9% there were two-and-a-half times as many girls as boys.

### *Referral Bias*

Ackerman and Dykman (1993) note some findings that sex prevalence ratios for reading are less in population studies of poor readers than in school referred or clinical samples of reading disability. This is often attributed to a referral bias (Prochnow, Tunmer, Chapman & Greaney, 2001; Sanson, Prior & Smart, 1996) related to the prevalence of behavioural problems in boys (Shaywitz, Shaywitz, Fletcher & Escobar, 1990). Research shows that more boys than girls are referred to specialist reading services (Prochnow, Tunmer, Chapman & Greaney, 2001) but that girls who are referred have more severe reading difficulties than boys (Vogel, 1990). Vogel reviewed data which indicated that, on average, girls were referred 1 year later than boys and were 1.5 years more delayed in reading as measured by the Wide Range Achievement Test (Jastak & Wilkinson, 1984). Shaywitz, Shaywitz, Fletcher and Escobar (1990) tested the hypothesis that the increased prevalence of reading disability in boys compared with girls reflected a bias in subject selection. From an epidemiological sample of 414 children they identified two reading disabled groups: research identified and school identified. Results indicated no significant sex differences in the prevalence of reading disability in second and third grade children identified on the basis of reading performance on the Woodcock-Johnson Reading Achievement Test (Woodcock & Johnson, 1989) but there was a sex bias of 3.00 towards boys in the group identified by teachers as reading disabled.

However Rutter et al. (2004) reviewed the history of research on sex differences in reading from four large independent epidemiological studies, with a total of 9,799

participants, in New Zealand, the United Kingdom and the United States, and provided evidence from these studies, that reading disability is significantly higher in boys than girls whether an IQ-referenced or a non-IQ-referenced criterion of reading disability is used. The authors state that on the basis of these epidemiological findings there is now sufficient evidence for a firm statement that reading disability is truly more frequent in boys than girls and research is needed to determine the causal influences that underlie this sex difference.

### *Reading Disability and Behavioural Problems*

A large number of studies have looked at the relationship between behavioural problems and reading disability (Hinshaw, 1992; Prior, Sanson, Smart & Oberklaid, 1995) and have shown that a high percentage of children with behavioural problems also have problems with reading. An obvious issue that relates to this co-morbidity is the question of which comes first. Do behavioural problems precede reading problems, thereby reducing a child's ability to concentrate and learn, or does reading disability make a child more prone to developing behavioural problems? Rutter, Tizard and Whitmore (1970) proposed four alternative "causal" hypotheses: 1) problem behaviour leads to reading difficulties; 2) reading disability produces behaviour problems; 3) both problem behaviour and reading disability are produced by some third factor; 4) all of these hypotheses could be partly true.

In his review of this area Hinshaw (1992) states that conceptual and measurement issues surround externalising behaviour problems and academic underachievement but the evidence suggests that antecedent variables such as low socioeconomic status, family adversity, below-average IQ, language deficits, and neurodevelopment delay are important underlying factors in any attempt to explain the association between the two. Hinshaw suggests two major types of externalising

behaviour: inattention and hyperactivity being one type, and aggression-conduct problems being the other, with inattention-hyperactivity being a more consistent correlate of underachievement. A study by DuPaul (1991) points to a link between early conduct disorders and later juvenile offending, while attention deficits are linked to academic underachievement in middle childhood.

### *Reading and Attention*

Attentional problems in children have attracted a lot of research with many studies looking at children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). This term refers to a behavioural syndrome characterised by inattention, impulsivity and hyperactivity which is described in the *Diagnostic and Statistical Manual for Mental Disorders-Fourth Edition*, (DSM-IV; American Psychiatric Association, 1994). Studies have reported a relationship between reading disabilities and ADHD in school children (Hinshaw, 1992; Bennett, Shaywitz & Shaywitz, 1991; Willcutt & Pennington, 2000) with estimates of comorbidity approaching 50% (Shaywitz & Shaywitz, 1991). Longitudinal studies have also indicated that preschoolers with problems of attention and hyperactivity have lower levels of reading in primary school (Horn & Packard, 1985; Kellam et al., 1991; McGee, Partridge, Williams & Silva, 1991; Vaughn, Hogan, Lancelotta, Shapiro & Walker, 1992; Velting & Whitehurst, 1997).

Studies of children who are not diagnosed with ADHD also show a relationship between reading disability and problems with attention. Lam and Beale (1991) tested 174 children aged 7-10 years on the Progressive Achievements Test, a test of reading comprehension and vocabulary for New Zealand primary and intermediate children. Classroom behaviour was rated on the Conners' Teaching Rating Scale (Conners, 1969). Results showed that ratings on the inattention factor of the rating scale were



significantly correlated with reading scores. In a study of 4,148 children Merrell and Tymms (2001) asked teachers to rate children on a rating scale based on the DSM-IV criteria of ADHD and calculated scores for inattention, hyperactivity and impulsivity. Results showed that it was the inattention element rather than the level of hyperactivity that was the most important factor associated with mathematics and reading underachievement. They suggest that this finding is consistent with the research of Gaub and Carlson (1997a) who found that hyperactive and impulsive children are not academically impaired.

In a longitudinal study of 387 children from kindergarten to fifth grade Rabiner and Coie (2000) conducted assessments of attention problems and reading achievement at multiple time points. Attention problems predicted reading achievement even after controlling for prior reading achievement, IQ and other behavioural difficulties. Inattentive first graders with normal reading scores after kindergarten were at risk for poor reading-outcomes. These results were replicated in a sample of children considered at high risk for conduct problems in a follow-up study of 581 children by Rabiner and Malone (2004). In this longitudinal multisite investigation Rabiner and Malone reported that attention problems predicted diminished reading achievement scores at the end of Grade 1 even after controlling for IQ and earlier reading ability. This consistent link between attention problems and academic underachievement suggests that investigations of children's achievement may benefit from including an assessment of children's attentional abilities aimed at identifying the kinds of attentional problems that are associated with underachievement. However assessment of attention poses a number of challenges:

## *Attention*

*Definition of Attention.* Many different approaches exist to the study of attention, and there is no single accepted definition of this concept and little agreement on assessment measures. Van Zomeren and Brouwer (1992) outline some of the difficulties of defining attention by examining the use of the word both colloquially and scientifically: in everyday language “paying attention” is primarily used to denote directed and selective perception but it also suggests a quantitative aspect in that a situation requires a certain amount of attention to be paid to it. Colloquial use of the word “attention” to denote concentrating hard on a task suggests effort and the layman’s use of the word also encompasses the idea of time-on-task effects and appreciation of the role of fatigue: no one is surprised when the audience stops attending to a boring talk or a person is unable to maintain concentration after a poor night’s sleep. These aspects of direction, selectivity, quantity, effort and time are all incorporated in the terminology of cognitive psychology which elaborates upon them as well as adding some other aspects such as alternating attention and executive control of attention. The net result is that although individual investigators may adopt a narrow definition of attention, excluding any aspect not relevant to their studies, the broad consensus is that attention is not a single cognitive function but rather a name for a variety of psychological phenomena with “no single, correct definition” (van Zomeren & Brouwer, 1992).

Parasuraman (1998) has suggested that attention may be thought of as several different capacities or processes that are related aspects of how the organism becomes receptive to stimuli and how it may begin processing incoming or attended-to excitation, whether internal or external.

A salient characteristic of attention is its limited capacity. Attentional capacity may vary between individuals as well as in the same individual at different times under different conditions such as fatigue or depression. Simple attention span is a relatively effortless process and has been shown to be fairly resistant to change as a result of aging and many brain disorders (Howieson & Lezak, 2002). Lezak, Howieson and Loring (2004) suggest that some aspects that are more easily disrupted, and therefore the focus of greater clinical and research interest, are focused or selective attention, sustained attention, divided attention and alternating attention.

*Selective Attention.* Focused or selective attention, which is commonly referred to as concentration, is the capacity to selectively attend to certain stimuli while suppressing awareness of competing distractions (Lezak, Howieson & Loring, 2004). This may be selection from one category of stimuli, such as picking ripe berries where colour is the discriminant feature, or from concurrent sources of information, such as following a conversation in a cocktail party situation when numerous other conversations compete for attention. Closely related to focused attention is the concept of distraction by factors irrelevant to the task.

*Sustained Attention.* Sustained attention is the capacity to maintain attention over time (Lezak, Howieson & Loring, 2004). When a person is engaged in a task his or her performance may change over time. It may improve due to practice effects and decline due to fatigue, boredom or drowsiness. Psychologists have typically been concerned with the negative effects of time-on-task which were studied in early work by Mackworth (1950) as a result of concern about the decreasing performance over time, of military personnel working with radar and sonar. Tasks such as these where stimuli are infrequent are called vigilance tasks. When stimuli are frequent the task is referred to as monitoring.

*Divided Attention.* Divided attention involves the ability to respond to more than one task at a time or to multiple elements or operations within a task (Lezak, Howieson & Loring, 2004). Because human beings have a limited capacity this may result in decreased performance on one or both tasks. Shiffrin and Schneider (1977) draw a distinction between processes that are automatic and can be carried out in parallel with other tasks and those which are controlled. Automatic processes may be due to inborn capacities or may be processes that have become automatic as a result of learning. For example a skill such as driving which has become automatic as a result of learning may be performed at the same time as listening to the radio. An alternative view is Treisman's feature integration theory (Treisman & Gelade, 1980, Treisman, 1993) which proposes that stimuli are processed in two successive stages. In the preattentive stage fundamental aspects such as colour, contrast and brightness are responded to immediately and automatically. In the second stage attention serves to combine features occupying the same location into unified objects. This implies that a person must focus attention on a stimulus in order to synthesize its features into a meaningful pattern.

*Alternating Attention.* The ability to switch attentive focus in a flexible and adaptive manner is commonly referred to as alternating attention or attentional switching. A child in school employs this ability when he or she is required to stop one task such as reading and focus attention on another such as arithmetic. This ability is considered by some investigators to be part of executive function and it is sometimes referred to as cognitive flexibility or the ability to shift cognitive set.

### *Models of Attention*

A number of investigators have proposed models of attention in which processing occurs sequentially in a series of brain systems in which different functions

are assigned to different brain regions (Butter, 1987; Mirsky, 1987; Posner & Peterson, 1990). Disorders of attention may arise from lesions involving different points in this system (Posner & Peterson, 1990; Robertson & Rafal, 2000; Rousseaux, Fimm & Cantagallo, 2002). Based on lesion and functional brain imaging studies Posner and Peterson (1990) proposed that there is evidence for at least three attentional systems: a posterior system responsible for the process of orienting, shifting and spatial selection; an anterior system responsible for target detection; and a third system responsible for sustained alertness to process high priority signals. This suggests that damage or inefficiency in one system will not automatically lead to poor functioning in another and implies that quite distinct patterns of attentional problems may occur in different individuals requiring different methods to assess them.

#### *Assessment of Attention*

Methods of assessing attentional abilities fall into two broad categories: rating scales and cognitive tests.

*Rating Scales.* Rating scales provide specific criteria for behavioural observations. Investigators using this method commonly ask teachers or parents to rate children's behaviour and may do so using a standard rating scale. Some of these scales are based upon the diagnostic criteria for ADHD, given in recent editions of the DSM, even when assessing attention in non-clinical or non-referred samples. Examples of rating scales are the Child Behaviour Checklist (Achenbach, 1991), the Conners' Rating Scales-Revised (Conners, 1997), the Behavioural Rating Inventory (Rowe & Rowe, 1995) and the AD/HD Rating Sale-IV (DuPaul, Power, Anastopoulos & Reid, 1998).

Rating scales offer a quick and easy format for assessing behaviours, are economical in terms of cost and time, and reduce rater bias and subjectivity by using

standardised presentation of questions. The more commonly used rating scales such as the Conners' Rating Scales and the AD/HD Rating Scale-IV have been the subject of extensive research and review and have been shown to have strong psychometric properties (Collett, Ohan & Myers, 2003).

However Rowe and Rowe (1992) in their review of methodological issues and analytical problems associated with research in the area of inattentiveness and reading achievement outline a number of areas of concern, one of which is the almost exclusive use of negative rather than positive behaviours in rating scales. They suggest that emphasis on negative nomenclature is at the expense of a more balanced assessment and may increase the risk of searching for pathology regardless of its presence or absence. A related problem is sociocultural differences. Hensley (1988) found a consistent tendency by Australian parents to rate their child's behaviour towards the negative end of items on the Achenbach Child Behaviour Checklist compared with North American parents and Reid, Casat, Norton, Anastopoulos and Temple (2001) found that African American children received higher scores than white children on teacher ratings of inattention, overactivity and aggression. Sandoval (1981) has shown that for positively worded items raters are more willing to use the extreme ends of the scale thus increasing the dispersion and discrimination of the measurements.

Halo/horns effect refers to a common source of psychometric error where characteristics, other than those specifically being measured, influence scores on a rating scale. Abikoff, Courtney, Pelham and Koplewicz (1994) suggest this is a particular problem with scales designed for teachers to measure attentional problems because children presenting with almost any disruptive behaviour tend to be rated higher on "attentional problems" even when the problematic behaviours are unrelated to inattentiveness or overactivity.

*Cognitive Measures.* A different approach to measuring attentional abilities is to attempt to standardise situational variables by using cognitive or neuropsychological tests. In contrast to neuropsychological tests of intelligence and memory, which have a long history of development, assessment of attention has been long neglected in psychology (van Zomeren & Brouwer, 1994). One reason for this is that attention is not directly measurable and can only to be assessed using a task hypothesised to make a demand on some aspect of attention. Van Zomeren and Brouwer (1992) make the point that “there are no tests of attention .... One can only assess a certain aspect of human behavior with special interest for its attentional component.” What is measured is behaviour, such as counting or response speed, and the attentional component is an inferred construct. For example when studying the efficiency of signal detection in a vigilance test the effect of each task variable, such as duration and discriminability, is assumed to tell us something about an aspect of attention. However because a particular task is never assessing “attention” only, other variables may influence performance and obscure the role of the attentional component.

This is particularly apparent when considering the distinction between attention and memory. The Digit Span subtest of the Wechsler Intelligence Scales (Wechsler, 1997, 2003) for example, is usually considered a test of working memory but appears in a study by Wade, Wood and Hewer (1988) as a test of attention. This highlights the fact that memory and attention are intertwined in ways that make them hard to distinguish on tests of information processing ability. When required to remember digits a person must hold them in working memory. At the same time the information presents a load to the person’s limited attentional capacity so this task can also be regarded as a test of attention. It follows therefore that Digit Span may not be a pure

measure of either short term memory or attention as poor scores on this test may be attributed to memory or attentional limitations or to a combination of both.

A related problem is that although a test may be described as a test of selective attention or a test of sustained attention, most cognitive measures require more than one aspect of attention for their performance. For example a visual search task which is used to measure selective attention, will also require the person performing it to be alert and sustain attention for several minutes in order to finish the task. Obviously the aim in designing tests of attention is to overcome these problems: the question is how successfully this can be done.

There are many cognitive tests that purport to measure different aspects of attention using a variety of tasks. Focused or selective attention is usually tested by manipulating distraction, using tasks in which target stimuli are embedded in an array of conflicting and inappropriate responses. Examples are cancellation tasks such as the d2 Test of Attention (Brickenkamp & Zillmer, 1998); tasks that require rapid scanning and identification of targets such as the Digit Symbol subtest of the Wechsler Intelligence Scales; and tasks with a distracting load such as Stroop tests (Stroop, 1935; Jensen & Rohwer, 1966). Sustained attention is frequently measured on computerised tasks in which the participant responds to randomly presented visual or auditory stimuli by pressing appropriate switches. These tasks are commonly referred to as continuous performance tasks: examples being the Conners' Continuous Performance Test (Conners, 1995), and the Test of Variables of Attention (Greenberg & Waldman, 1993). Divided attention may be assessed by combining two or more tasks in one test, as for example in dichotic listening tasks, or by tests that require division of attention between subtasks such as the Paced Auditory Serial Addition Task (PASAT; Gronwall, 1977). Alternating attention is measured on tasks, such as the Wisconsin Card Sorting



Test (WCST; Berg, 1948), that require flexibility as responses have to vary according to criteria that are constantly changing. However this type of task is also considered to be a test of executive function, again questioning the specificity of tests of attention.

*Children's Versions of Cognitive Tests of Attention.* The use of cognitive tests to assess attention in children poses a particular challenge, because developing children may be expected to show greater variability than adults in cognitive abilities, such as motor skill, task comprehension and language, thereby increasing the requirement for these non-attentional variables to be minimised in order for the attentional component of the task to be measured. At the same time there is a need for the stimulus materials to be engaging in order to motivate children to perform to the best of their ability.

Other concerns are the limited number of tests that have a children's version and the fact that some of the tests that are available in children's versions such as the CHIPASAT (Dyche & Johnson, 1991), the children's version of the PASAT, may not be suitable for studies which involve measurement of academic abilities because of their documented association with intelligence (Crawford, Obonsawin & Allan, 1998) or with arithmetic ability (Dyche & Johnson, 1991), or because of a prerequisite of reading skill or arithmetic ability as is the case with Stroop tests and the CHIPASAT.

In order to try to overcome some of these difficulties Manly, Robertson, Anderson and Nimmo-Smith, (1999) have developed the Test of Everyday Attention for Children (TEA-Ch), a standardised and normed clinical battery of tests for children between the ages of 6 and 16, that provides measures of selective attention, sustained attention and attentional control/switching. As part of the collection of norms for this test, Manly, Anderson, Nimmo-Smith, Turner, Watson and Robertson (2001) examined the performance of a sample of 24 boys diagnosed with Attention Deficit Disorder (ADD) and found specific deficits in sustained attention were apparent while selective

attention performance was within the normal range. Other researchers have explored the utility of the test as a measure of the attentional impairments displayed by children with ADHD (Heaton et al., 2001; West, Houghton, Douglas & Whiting, 2002) and with primary school children to assess a range of attentional functions (Imada, Komatsu & Takahashi, 2003).

In a study of 100 primary school children Wilding, Munir and Cornish (2001) attempted to see how closely distinct components of attention identified through cognitive tests are related to teacher ratings of general attention in the classroom. Two groups of children, one with good attention and low hyperactivity and the other with poor attention and high hyperactivity, were differentiated on the basis of teacher ratings. After statistically controlling for intelligence the two groups demonstrated significant differences on a variety of cognitive tests, some from the TEA-Ch and some from another battery developed for children (Wilding, unpublished). The authors conclude that several of the objective laboratory measures support the more general subjective teacher ratings. Alternatively it might be said that this association lends some support to the validity of the cognitive tests of attention.

#### *Future Directions for Research*

Although a number of studies have indicated that cognitive tests may be a useful means of assessing a range of attentional abilities in children, investigations of the relationship between children's ability to pay attention and their academic achievement have typically used only parent or teacher ratings of attention. Furthermore there have been few attempts to compare cognitive measures of attention with rating scales or to evaluate which of them best measures different aspects of attention.

Another potentially important factor which has often been ignored in investigations of children's attentional abilities is differences across subject areas. The

majority of studies focus on one area of academic achievement, commonly reading. Thus it is unclear if different aspects of attention vary in their relationship to achievement as a function of subject area. Given that teaching methods and work assignments in different subjects may differ in terms of mode of delivery, task expectation and types of child teacher interactions this may be an important distinction. For example one possibility is that the relevant aspect of attention might be specific to reading instruction and not to maths instruction and this may account for differences in children's abilities in these areas and the different patterns of achievement found in girls and boys for reading and maths.

Future research looking at sex differences in children's attentional abilities would also be valuable. Most of the studies in this area are with clinical populations of children and may not reflect sex patterns in the broader population (Gaub & Carlson, 1997b; Graetz, Sawyer & Baghurst, 2005). Studies of sex differences in specific attentional abilities in a normal population could help to explain differences in children's other abilities. It is possible, for example, that specific attentional difficulties in boys in the early school years may contribute to their poorer performance in reading compared to girls.

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## **Empirical Study**

The relationship between attention and achievement in reading and numeracy

## Abstract

The aim of this study was to examine the relationship between children's ability to pay attention and their achievement in reading and numeracy using two different measures of attention: teacher ratings and cognitive tests. Sixty Grade three children (28 boys and 32 girls) were tested on measures of selective attention, sustained attention and attentional switching from the Test of Everyday Attention for Children (TEA-Ch), the Martin and Pratt Nonword Reading Test, an Irregular Word Test and a Maths Test. Teachers were asked to rate children on a Rating Scale designed to measure motivation, selective attention, sustained attention, co-operation with their teacher, over-activity and ability to switch attention. The results obtained show significant correlations between teacher ratings of attention and children's achievement in reading and numeracy. Children's scores on the cognitive tests of attention show only weak relationships with their scores on measures of achievement in both reading and numeracy and very low correlations with teacher ratings of their ability to pay attention in the classroom. It is suggested that these low correlations may be partly due to the limitations of attempting to measure attention with cognitive tests that are administered in a quiet structured environment that places limited demands on a child's attentional capacity. This study highlights the need for valid and objective measures of attention that are not contaminated by a perception of performance and that capture what it is that teachers see when they assess a child's ability to pay attention in class.



Reading skills are a vital part of everyday functioning as well as being the foundation of academic success in our society and children who fail to learn to read or who have significant problems in this area in early primary school have been shown to be at risk for a variety of poor academic, social and psychological outcomes (Hinshaw, 1992). This has motivated researchers to attempt to identify factors that impinge on reading problems with a view to identifying possible causal mechanisms and developing preventative and remedial strategies.

Early research into reading development pointed to sex differences in reading performance (Berger, Yule, & Rutter, 1975; Thompson 1975). Although some studies found no difference in the mean reading attainment of boys and girls under ten, there were a greater proportion of boys than girls among pupils of very low reading attainment. A more recent investigation (Alexander & Martin, 2000) found that females average about 2 points higher on tests of basic reading skills but this is due to a male disadvantage at the bottom end of the distribution, not in the top where there appears to be no difference between boys and girls reflecting a higher standard deviation for boys. This should not, however, be interpreted as a male disadvantage in all academic subjects. Studies looking at sex differences in mathematical achievement have found that boys are not disadvantaged in numeracy (Feingold, 1996) and in some areas may perform better than girls (Manger, 1995). These differences are confirmed in population studies which show that boys have a slightly lower mean and a greater variability in reading than girls; which means that more boys fall into the lower part of the distribution and when a low benchmark for reading is used more boys than girls will fail to reach it. The figures for grade three children in Australia in 2001 (Ministerial Council on Education, Employment, Training and Youth Affairs, 2001) show that 12.2% of boys did not achieve the Australian benchmark for reading

compared with 8% of girls. The benchmark figures for numeracy, on the other hand, show comparable figures for the two sexes. In 2001, 6.3% of Grade 3 boys failed to achieve the Australian benchmark compared with 5.7% of girls.

It is well established that there are more boys referred to specialists with reading problems than girls (Prochnow, Tunmer, Chapman & Greaney, 2001; Sanson, Prior & Smart, 1996; Shaywitz, Shaywitz, Fletcher & Escobar, 1990) but it has been shown that boys referred are less handicapped in reading than girls (Vogel, 1990) and have more behaviour problems in school (Shaywitz, Shaywitz, Fletcher & Escobar, 1990). However the definition of behavioural problems has varied widely: some researchers have used antisocial behaviour to define children with behaviour problems while others have looked at children with attention-deficit/hyperactivity disorder (ADHD). ADHD is a diagnostic category used to describe individuals who display developmentally inappropriate levels of inattention, impulsivity, and/or motor activity (American Psychiatric Association, 1994). Studies have reported a significant degree of association between reading disabilities and ADHD in school children (Hinshaw, 1992; Bennett, Shaywitz & Shaywitz, 1991; Willcutt & Pennington, 2000) with estimates of comorbidity approaching 50% (Bennett, Shaywitz & Shaywitz, 1991).

Longitudinal studies have also indicated that preschoolers with problems of attention and hyperactivity have lower levels of reading in primary school (Horn & Packard, 1985; McGee, Partridge, Williams & Silva, 1991; Velting & Whitehurst, 1997). A study of 364 children aged 8 to 11 years by Adams, Snowling Hennesy and Kind (1999) showed strong evidence of an association between negative behaviour and low attainment. In particular, hyperactivity was negatively correlated with both reading and arithmetic. Conversely, prosocial behaviour was positively correlated with academic attainment. However it has been suggested that inattention and impulsivity

are distinct factors in analyses of teacher and parent behaviour ratings (DuPaul, 1991), and hyperactivity may be expressed in the context of problems with inattention or impulsivity but does not occur in their absence. In a study of 4,148 children, who were not diagnosed with ADHD, Merrell and Tymms (2001) found that it was the inattention element of the behaviour in question that was the most important factor associated with mathematics and reading underachievement. They suggest that this finding is consistent with the research of Gaub and Carlson (1997) who found that hyperactive and impulsive children are not academically impaired. In a longitudinal study of 387 children from kindergarten to fifth grade Rabiner and Coie (2000) conducted assessments of attention problems and reading achievement at multiple time points. Attention problems predicted reading achievement even after controlling for prior reading achievement, IQ and other behavioural difficulties. Inattentive first graders with normal reading scores after kindergarten were at risk for poor reading outcomes. These results were replicated in a sample of children considered at high risk for conduct problems in a follow-up study of 581 children by Rabiner and Malone (2004). In this longitudinal multi-site investigation Rabiner and Malone reported that attention problems predicted diminished reading achievement scores at the end of first grade even after controlling for IQ and earlier reading ability. Investigations of children's achievement may therefore benefit from including an assessment of children's attentional abilities aimed at identifying the kinds of attentional problems that are associated with academic underachievement.

However attention is not a single cognitive function and there is little agreement as to the definition of attention or how it can be measured. Many investigators conceive of attention as a system in which processing occurs sequentially in a series of brain systems organised in a hierarchical manner in which the earliest entries are

modality specific while later stages are supra-modal (Butter, 1987, Posner & Peterson, 1990). Disorders of attention may arise from lesions involving different points in this system (Robertson & Rafal, 2000). On the basis of lesion and functional imaging studies Posner and Peterson (1990) proposed that there was good evidence for at least three attentional systems which can be characterised as selective attention, sustained attention, and spatial attention. This suggests that damage or inefficiency in one system will not automatically lead to poor functioning in another and implies that quite distinct patterns of attentional problems may occur in different individuals requiring different methods to assess them.

Some of the aspects of attention that have received the greatest attention are focused or selective attention, sustained attention, divided attention and alternating attention (Lezak, Howieson & Loring, 2004). Lezak, Howieson and Loring give the following definitions for these terms: focused or selective attention, which is commonly referred to as concentration, is the capacity to selectively attend to certain stimuli while suppressing awareness of competing distractions; sustained attention is the capacity to maintain attention over time; divided attention involves the ability to respond to more than one task at a time or to multiple elements or operations within a task; alternating attention, allows for shifts in focus and task and is also referred to as attentional switching.

Methods of measuring of attentional abilities fall into two broad categories. One category is behavioural observation using rating scales for specific criteria. Investigators using this method commonly ask teachers or parents to rate children's behaviour and may do so using a standard rating scale. Some of these rating scales are based upon the diagnostic criteria for ADHD given in recent editions of the DSM even when measuring inattention in non-clinical or non-referred samples. Examples of

rating scales are the Child Behaviour Checklist (Achenbach, 1991), the Conners' Rating Scales-Revised (Conners, 1997), the Behavioural Rating Inventory (Rowe & Rowe, 1995) and the AD/HD Rating Scale-IV (DuPaul, Power, Anastopoulos & Reid, 1998). Although they have been criticised for their focus on negative rather than positive behaviours (Rowe & Rowe, 1992a) and their lack of sensitivity to social and cultural differences (Hensley, 1998; Reid, Casat, Norton, Anastopoulos & Paige, 2001) many of these scales have well established psychometric properties because of their history of use in both clinical and research settings.

Another approach to measuring attentional abilities is the use of cognitive or neuropsychological tests, a wide variety of which purport to measure attention using a variety of tasks from speed of information processing and measures of vigilance to visual search paradigms and tasks with a distracting load. Focused or selective attention is usually tested by manipulating distraction using tasks in which target stimuli are embedded in an array of conflicting and inappropriate responses such as cancellation tasks, an example of which is the d2 Test of Attention (Brickenkamp & Zillmer, 1998); tasks that require rapid scanning and identification of targets such as the Digit Symbol subtest of the Wechsler Intelligence Scales (Wechsler, 1997, 2003); and tasks with a distracting load such as Stroop tests (Stroop, 1935; Jensen & Rohwer, 1966). Sustained attention is frequently measured using continuous performance tasks, examples of which are the Conners' Continuous Performance Test (Conners, 1995), and the Test of Variables of Attention (Greenberg & Waldman, 1993). Divided attention may be assessed by combining two or more tasks in one test, as for example in dichotic listening tasks, or by tests that require division of attention between subtasks such as the Paced Auditory Serial Addition Task (PASAT: Gronwall, 1977). Alternating attention is measured on tasks, such as the Wisconsin Card Sorting Test

(Wisconsin Card Sorting Test (WCST: Berg, 1948) that require flexibility as responses have to vary according to criteria that are constantly changing.

However, most cognitive measures of attention do not distinguish clearly between different aspects of attention or between attention and other cognitive abilities. This is particularly apparent when considering the distinction between attention and memory. Digit Span for example is usually considered a test of working memory but appears in a study by Wade, Wood and Hewer (1988) as a test of attention. This highlights the fact the working memory and attention are intertwined in ways that make them hard to distinguish when considering information processing tasks. For example when required to remember digits a person must hold them in working memory. At the same time the information presents a load to the individual's limited attentional capacity so this task can also be regarded as a test of attention. It follows therefore that Digit Span may not be a pure measure of either short term memory or attention as poor scores on the test may be attributed to memory or attentional limitations or to a combination of both.

Another problem is that each test will inevitably tap several aspects of attention. For an example a visual search task which is thought to measure selective attention, will also require the person performing it to be alert and sustain attention for several minutes in order to finish the test. Obviously the aim in designing tests of attention is to overcome these problems; the question is how successfully this can be done.

An additional complication when working with children is the limited number of tests that have a children's version and the fact that some of the tests that are available in children's versions such as the CHIPASAT (Dyche & Johnson, 1991), the children's version of the PASAT, may not be suitable for studies which involve measurement of academic abilities because of their documented association with intelligence

(Crawford, Obonsawin & Allan, 1998) or with arithmetic ability (Dyche & Johnson, 1991), or because of a prerequisite of reading skill or arithmetic ability as is the case with Stroop tests and the CHIPASAT.

In order to try to overcome some of these difficulties Manly, Robertson, Anderson and Nimmo-Smith (1999) have developed the Test of Everyday Attention for Children (TEA-Ch), a standardised and normed clinical battery of tests for children between the ages of 6 and 16, that provides measures of selective attention, sustained attention and attentional control/switching. As part of the collection of norms for this test, Manly, Anderson, Nimmo-Smith, Tuner, Watson and Robertson (2001) examined the performance of a sample of 24 boys diagnosed with Attention Deficit Disorder (ADD) and found specific deficits in sustained attention were apparent while selective attention performance was within the normal range. Other researchers have explored the utility of the test as a measure of the attentional impairments displayed by children with ADHD (Heaton et al., 2001; West, Houghton, Douglas & Whiting, 2002) and with primary school children to assess a range of attentional functions (Imada, Komatsu & Takahashi, 2003).

A study of 100 primary school children by Wilding, Munir and Cornish (2001) attempted to see how closely distinct components of attention identified through cognitive tests are related to teacher ratings of general attention in the classroom. Two groups of children, one with good attention and low hyperactivity and the other with poor attention and high hyperactivity, were differentiated on the basis of teacher ratings. After statistically controlling for intelligence the results of this study show that the two groups demonstrated significant differences on a variety of cognitive tests, some from the TEA-Ch and some from another battery developed for children. The authors conclude that several of the objective laboratory measures support the more

general subjective teacher ratings. Alternatively it might be said that this association lends some support to the validity of the cognitive tests.

Although the results obtained by Wilding and his associates indicate that cognitive tests may be a useful means of measuring attention in children, prior investigations of the relationship between children's ability to pay attention and their academic achievements have typically used only teacher or parent ratings of attention. Furthermore there have been few attempts to compare different measures of attention or to indicate which measures best assess different aspects of attention. Another potentially important factor which has often been ignored in previous investigations is differences across subject areas. The majority of studies focus on one area of academic achievement, commonly reading. Thus it is unclear if different aspects of attention vary in their relationship to achievement as a function of subject areas. For example one possibility is that the relevant aspect of attention might be specific to reading instruction and not to arithmetic instruction and this may account for differences in children's abilities in these areas and the different patterns of sex differences found in reading and numeracy achievement.

The present study aims to investigate these relationships by examining the correlations between teacher ratings of children on different aspects of attention, their results on cognitive tests of attention and their scores on attainment measures in reading and numeracy. Three subtests of the TEA-Ch were used to measure selective attention, sustained attention and attentional switching. Teacher ratings were designed to measure selective attention, sustained attention and attentional switching as well as more general aspects of motivation, co-operation with their teacher and over-activity.



## Method

### *Participants*

Sixty Grade 3 children from three schools, 28 boys and 32 girls ranging in age from 8/1 to 10/0. The median age of the children was 9/0. Children taking medication that could affect cognitive processes, such as Methylphenidate (Ritalin), were excluded from the study. All three schools are located in Southern Tasmania, Australia.

### *Materials*

*Cognitive Measures.* Children were tested on three subtests (Sky Search, Score and Opposite Worlds) of the Test of Everyday Attention for Children (TEA-Ch; Manly, Robertson & Nimmo-Smith, 1999). Sky Search is a brief, timed test of selective attention in which children are required to identify 20 pairs of identical spaceships distributed among 108 distracter pairs. Both speed and accuracy are emphasised and termination of the task is self-determined by the children marking a box in the corner of the test sheet when they have finished. Score is a 10-item tone-counting measure in which children are asked to silently count tones and to give the total at the end. Because the task is simple and there are long gaps between sounds, children are required to self-sustain their own attention. Opposite Worlds is a measure of attentional switching in which children are required to switch the focus of attention between one thing and another. In the Same World condition children name the digits 1 and 2 that are randomly shown on a path. In Opposite World they do the same task but are required to perform the cognitive reversal of saying 'one' when they see 2 and saying 'two' when they see 1. Because it takes significantly longer for children to complete the Opposite World than the Same World condition, this test is also a measure of children's ability to inhibit the automatic or "prepotent" verbal response

*Tests of Reading.* Children were tested using the Martin and Pratt Nonword Reading Test (Martin & Pratt, 2001), a test of phonological recoding skills, and the Irregular Word Test (Alexander & Drinkwater, Unpublished: Appendix A), a test of orthographic processing skills.

*Tests of Numeracy.* Children were tested on a Maths Test which was composed of the first eight items of each of the two versions (Blue and Tan) of the Written Arithmetic section of the Wide Range Achievement Test (WRAT; Jastak & Wilkinson, 1984). Computations that are given in a vertical format in the WRAT were changed to a horizontal format because schools in Tasmania do not teach children to calculate using a vertical format until Grade 3 or Grade 4.

*Teacher Ratings.* A Teacher Ratings Scale was constructed to measure nine aspects of children's abilities, motivation and behaviour in the classroom. This comprised a Teacher Ratings Form (Appendix B) with space for teachers to rate each child participating in the study, on each aspect being measured, on a seven-point Likert scale, and an accompanying Instruction Sheet (Appendix C) containing definitions for each of the items on the scale.

Two of the items on the Teacher Ratings Scale, "Concentration in reading" and "Concentration in maths" were designed as measures of selective attention. The definitions for these were "ability to remain 'on task' and not be distracted during reading" and "ability to remain 'on task' and not be distracted during maths". Two of the items, "Attention in reading" and "Attention in maths" were designed as measures of sustained attention with a definition of "ability to sustain attention and persevere with a reading task" and "ability to sustain attention and persevere with a maths task". One item was designed as a measure of children's ability to switch attention which was defined as a child finding it difficult "to leaving a task s/he is engaged in and

concentrate on something else”. The remaining items were designed to assess interest/motivation in reading and maths, over-activity and the level of co-operation with the teacher.

For each item definitions of the two extremes of the scale were given. For example for the item “Attention in reading” it was indicated that 1 is equivalent to a very short attention span when reading and 7 is equivalent to very good ability to sustain attention when reading. In this instruction sheet teachers were asked to rate children in comparison with the rest of the class and examples were given of what this would mean for an average class of 28 children as follows: 1 equates to one of the lowest four in the class, 2 equates to one of the lowest 8 in the class, 3 equates to below-average, 4 equates to average, 5 equates to above-average, 6 equates to one of the highest 8 in the class, 7 equates to one of the top 4 in the class.

### *Procedure*

Information Sheets and Parent/Guardian Consent Forms (Appendix D) were sent home with Grade 3 children in three schools. These forms explained the purpose of the study, gave details of how data would be collected and how confidentiality would be maintained and indicated that the study has received ethical approval from the Human Research Ethics Committee (Tasmania) Network and that the Tasmanian Department of Education has granted permission to conduct the research in Tasmanian state schools.

Teachers were asked if any of the children who returned forms granting parental permission for them to participate in the study were taking medication that affects cognitive processes. One child was excluded from the study on this basis. All other children who returned forms granting parental permission were included in the study.

Teachers were given a Teacher Rating Form with the names of all children from their class who were participating in the study and an accompanying Instruction Sheet. The researcher pointed out to teachers the different definitions that were provided for each of the nine items on the Form and asked them to spend some time, for example one to two weeks, considering the different items in the rating scale, together with their accompanying criteria, in relation to all the children in their class. After doing this they were requested to rate each child participating in the study in comparison to the rest of the children in their class on each of the items on the Teacher Rating Form.

Individual testing took approximately 40 minutes and was conducted by the researcher over two sessions in a quiet room in the school. The two sessions were conducted within the space of three weeks in all cases. The three sub-tests of the TEA-Ch were administered according to standard instructions from the manual in the first session. In the second session the Nonword Reading Test, the Irregular Word Test and the Maths Test were administered using standard instructions from the manual for each test. All tests were scored by the researcher.

## Results

The raw score for nonword reading ability (NonWord) was the number of items correctly read from the 54 items of the Martin and Pratt Nonword Reading Test. The raw score for irregular word reading ability (IrrWord) was the number of words correctly read from the 68 items of the Irregular Word Test. The raw score for the Maths Test (Maths) was the number of computations correctly answered (out of a possible maximum of 16). Raw scores for the three sub-tests of the TEA-Ch were calculated according to the standard procedures given in the Manual. For Score the raw score was the number of items (out of a possible maximum of 10) in which tones

were correctly counted. For Same World and Opposite World the raw scores were time in seconds. For Sky Search the raw score was the Sky Search Attention Score (time in seconds divided by the number of targets correctly identified on the Sky Search task minus time in seconds divided by the number of targets correctly identified on the motor control task). It was decided not to convert the raw scores to standard scores using the normative tables because separate norms are given for boys and girls and the present sample overlapped two different age categories. Scores for the three timed tests, were reversed and a logarithm was taken to correct the skew. Details of this procedure are given in Appendix E. The resultant measures are termed SkySeRL for Sky Search, SameWRL for Same World and OppWRL for Opposite World. This process was not performed for Score because it is not a timed test and is positively scored. The difference in the logarithms of the Same World and Opposite World tasks was used as a measure of children's ability to inhibit the automatic or "prepotent" response. This measure is termed SamOpWRL. The Teacher Ratings were used as obtained on the ratings sheets for all ratings except the Over-activity Scale, which is a negative one; this measure was reversed for correlational analyses and the resultant rating is termed NOverAc.

### *Sex Differences*

Table 1 shows the mean and standard deviation of all measures by sex. A multivariate MANOVA for all measures found the difference between boys and girls was not significant,  $F(16, 43) = 1.09, p = .4$ . ANOVAS found that the only difference that was individually significant was for maths: boys' scores were significantly higher,  $F(1, 58) = 4.7, p = .03$  but the reliability of this difference can be questioned given the number of hypotheses tested and the non-significant MANOVA for sex differences.

Table 1

*Mean and Standard Deviation of all Measures by Sex*

	Girls		Boys		Total		Range of Scores
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
<i>Attainment Measures</i>							
NonWord	34.72	11.85	34.68	10.40	34.70	11.10	9 - 54
Irrword	37.72	10.05	36.79	9.85	37.28	9.99	10 - 58
Maths *	9.16	3.22	10.93	3.07	9.98	3.25	4 -16
<i>Cognitive Measures</i>							
SkySeRL	6.75	1.69	6.17	1.60	6.48	1.66	1.9 – 11.2
Score	8.25	1.68	8.21	1.73	8.23	1.69	3 - 10
SameWRL	3.59	.57	3.56	.55	3.57	.56	2.2 – 4.6
OppWRL	4.69	.70	4.67	.63	4.68	.66	2.8 – 6.0
SamOpWRL	-1.10	.47	-1.11	.45	-1.10	.46	-1.9 - .1
<i>Teacher Ratings</i>							
IntRead	4.75	1.90	4.96	1.32	4.85	1.64	1 - 7
IntMath	4.28	1.71	4.96	1.37	4.60	1.59	1 - 7
ConRead	4.56	2.11	4.29	1.70	4.43	1.92	1 - 7
ConMath	4.16	1.83	4.54	1.69	4.33	1.76	1 - 7
AttRead	4.72	1.99	4.50	1.64	4.62	1.82	1 - 7
AttMath	4.44	1.79	4.75	1.51	4.58	1.66	1 - 7
AttSwit	4.84	1.72	4.71	1.46	4.78	1.60	1 - 7
Co-op	5.06	1.88	4.61	1.77	4.85	1.83	1 - 7
NOverAc	4.03	1.77	3.89	1.66	3.97	1.71	1 - 7

\* Sex difference is significant at the .05 level

### *Teacher Ratings*

Table 2 shows correlations between teacher ratings of children's interest (IntRead, IntMath), concentration (ConRead, ConMath) and attention (AttMath, AttRead) in maths and reading, children's level of co-operation with their teacher (Co-op), children's ability to switch attention (AttSwit) and children's over-activity (NOVerAc). As can be seen, almost all of these correlations are significant and are mostly moderate to high. Interest in reading is more related to attention in reading than it is to attention in maths although this difference is not significant  $t(57)=1.17$ ,  $p=.25$ . Interest in maths is more related to attention in maths than it is to attention in reading and this difference does reach significance,  $t(57)=2.90$ ,  $p=.005$ .

The correlations between the teacher ratings of concentration and attention in both reading and maths is particularly high (.94 for reading and .96 for maths) suggesting that teacher ratings did not differentiate attention and concentration. For this reason the score for concentration was not included in subsequent analyses.

Table 2

*Correlations between Teacher Ratings of Children's Classroom Behaviour*

	Int Read	Int Math	Con Read	Con Math	Att Read	Att Math	Att Swit	Co-op	NOve rAc
IntRead	1.00	.74**	.77**	.68**	.81**	.75**	.61**	.37**	.31*
IntMath	.74**	1.00	.69**	.85**	.71**	.85**	.65**	.31	.33**
ConRead	.77**	.69**	1.00	.73**	.94**	.74**	.63**	.50**	.26*
ConMath	.68**	.85**	.73**	1.00	.73**	.96**	.61**	.44**	.24
AttRead	.81**	.71**	.94**	.73**	1.00	.76**	.66**	.54**	.28*
AttMath	.75**	.85**	.74**	.96**	.76**	1.00	.62**	.43**	.24
AttSwit	.61**	.65**	.63**	.61**	.66**	.62**	1.00	.61**	.31
Co-op	.37**	.31*	.50**	.44**	.54**	.43**	.61**	1.00	.40**
NOverAc	.31*	.33**	.26*	.24	.28*	.24	.31*	.40**	1.00

\* Correlation is significant at the .01 level (2-tailed)

\*\* Correlation is significant at the .05 level (2-tailed)

*Cognitive Measures*

Table 3 shows inter-correlations between the cognitive measures of attention used in the study, and correlations between the cognitive measures and the teacher ratings of classroom behaviour. There is no significant correlation between the measure of selective attention (SkySeRL) and the measure of sustained attention (Score), there is a high correlation between the two measures of attention switching (SameWRL and OppWRL) and OppWRL is weakly but significantly correlated with the measure of selective attention (SkySeRL) and with the measure of sustained attention (Score). The measure of children's ability to inhibit the automatic response (SamOpWRL) shows a stronger correlation with the measure of sustained attention (Score) than the OppWRL scores do.



The cognitive measures of attention have little relationship to teacher ratings except for weak associations between the measures of selective attention (SkySeRL) and teacher ratings of interest and attention in reading and maths.

Table 3

*Correlations between Cognitive Measures and Teacher Ratings of Children's Classroom Behaviour*

	Cognitive Measures				
	SkySeRL	Score	SameWRL	OppWRL	SamOpWRL
<i>Cog. Measures</i>					
SkySeRL	1.00	.14	.23	.31*	.16
Score	.14	1.00	.07	.35**	.42**
SameWRL	.23	.07	1.00	.73**	.16
OppWRL	.31*	.35**	.73**	1.00	.55*
SamOpWRL	.16	.42**	.16	.55**	.24
<i>Teacher Ratings</i>					
IntRead	.27*	.09	.13	.12	.01
IntMaths	.26*	.06	.01	.12	.16
AttRead	.28*	.06	.19	.13	.05
AttMaths	.26*	.10	.03	.12	.13
AttSwit	.21	-.08	.06	-.01	.08
Co-op	.19	.00	.14	-.05	.24
NOverAc	.22	.09	-.03	-.04	.02

\* Correlation is significant at the .01 level (2-tailed)

\*\* Correlation is significant at the .05 level (2-tailed)

*Measures of Reading and Numeracy*

Table 4 shows correlations between children’s scores on the Nonword Reading Test, the Irregular Word Reading Test and the Maths Test. Scores on the Nonword Reading Test, a test of phonological recoding skills, are highly correlated with scores on the Irregular Word Test, a test of orthographic or lexical processing ability. The correlations between the children’s scores on the Maths Test and their achievement on the Nonword Test and the Irregular Word Test are moderate. The trend for scores on the Irregular Word Test to be more highly correlated with scores on the Maths Test than scores on the Nonword Reading Test does not reach significance,  $t(57)=1.89$ ,  $p=.064$ .

Table 4

*Correlations between Standard Measures of Reading and Maths*

	Non Word	Irregular Word	Maths
Non Word	1.00	.81**	.41**
Irregular Word	.81**	1.00	.54**
Maths	.41**	.54**	1.00

\* Correlation is significant at the .01 level (2-tailed)

\*\* Correlation is significant at the .05 level (2-tailed)

*Measures of Attention and Achievement*

Table 5 shows correlations between measures of attention and children’s achievement in reading and maths. Almost all of the correlations between teacher ratings and children’s achievement measures are significant. In particular all the teacher ratings are moderately to highly correlated with scores on the Irregular Word Test. Teacher ratings of children’s interest and attention in reading are moderately to highly correlated with their achievement in reading; with irregular word reading more related to teacher ratings than nonword reading. Teacher ratings of children’s interest

in maths and attention in maths are moderately to highly associated with their achievement in maths. Teacher ratings of children's ability to switch attention are weakly to moderately correlated to children's achievement in both reading and maths. Teacher ratings of co-operation are moderately associated with their achievement in reading but there is very little association between ratings of co-operation and achievement in maths. A rating of low over-activity is only weakly correlated with achievement measures in reading and maths.

The correlations between the cognitive measures of attention and children's achievement in reading and maths, as shown in Table 5, indicate only weak relationships between individual tests and selective abilities. There is a weak but significant association between the measure of selective attention (SkySeRL) and the Irregular Word Test but it is not associated with nonword reading or maths. There is a weak association between the measure of sustained attention (Score) and the results on the Maths Test. The measures of attentional switching (SameWRL and OppWRL) both have a weak association with nonword reading and to a lesser extent irregular word reading. Maths ability is moderately associated with the OppWRL measure of attentional switching and with the measure of children's ability to inhibit the automatic response (SaMOpWRL).

The range of correlations between teacher ratings of attention and children's achievement scores on the reading and numeracy tests was .26 to .61 with a median correlation of .47 whereas the correlations between their scores on the cognitive measures of attention and their scores on the reading and numeracy tests were mostly not significant, ranging from .17 to .34 with a median correlation of .23.

Comparison of within sample correlations indicates that only some of these differences are significant. For example both the Nonword Test and the Irregular

Word Test have significantly higher correlations with teacher ratings of attention in reading than with SkySeRL, the cognitive measure of selective attention,  $t(57)=2.20$ ,  $p=.032$  for the Nonword Test and  $t(57)=2.12$ ,  $p=.038$  for the Irregular Word Test. However the trend for scores on the Maths Test to be more highly correlated with teacher ratings of attention in maths than with Score, the cognitive measure of sustained attention, does not reach significance,  $t(57)=1.45$ ,  $p=.152$ . Given the relatively small  $n$  used in this study many of these differences are not reliable.

Table 5

*Correlations between Teacher Ratings, Cognitive Tests and Achievement Measures of Reading and Maths*

Measures of Attention	Measures of Achievement		
	NonWord	IrrWord	Maths
<i>Teacher Ratings</i>			
IntRead	.54**	.61**	.41**
IntMaths	.38**	.51**	.58**
AttRead	.48**	.61**	.45**
AttMaths	.41**	.49**	.52**
AttSwit	.38**	.54**	.26**
Co-op	.34**	.39**	.08
NOverAc	.16	.31*	.26*
<i>Cognitive Measures</i>			
SkySeRL	.17	.34**	.14
Score	.23	.11	.30*
SameWRL	.28*	.23	.08
OppWRL	.24	.20	.28*
SaMOpWRL	.01	.00	.31*

\* Correlation is significant at the .01 level (2-tailed)

\*\* Correlation is significant at the .05 level (2-tailed)

## Discussion

The aim of this study was to examine the relationship between children's ability to pay attention and their achievement in reading and numeracy using two different measures of attention, teacher ratings and cognitive tests. The teacher ratings were intended to be measures of motivation, selective attention, sustained attention, co-operation with the teacher, over-activity and ability to switch attention. The cognitive tests are reported to be measures of sustained attention, selective attention and attentional control/switching.

The results obtained show a relationship between both the teacher ratings of attention, and the cognitive tests of attention, and children's achievement in reading and numeracy but teacher ratings are more related to achievement than the cognitive measures of attention are. The correlations between teacher ratings of attention and children's achievement scores on the reading and numeracy tests had a median of 41 whereas the correlations between their scores on the cognitive measures of attention and their scores on the reading and numeracy tests had a median of 23. However not all of these differences are significant and a much larger study would be needed to establish reliable differences.

This study found no significant sex differences across all measures with the only difference that was individually significant being that boys scored higher than girls in maths. Large scale studies (Thompson 1975, Rutter et al., 2004) consistently show a small sex difference in literacy, girls being higher than boys, suggesting that a much larger study than this one would be needed to establish reliable sex differences.

Teacher ratings of over-activity were only weakly correlated with achievement measures in reading and maths and no consistent trend was found for boys to be lower in attention related measures than girls. This is in contrast to other studies which have

found over-activity and inattention to be strong predictors of academic underachievement (Hinshaw, 1992) and that boys are more prone than girls to disruptive and inattentive classroom behaviours that impede learning (DuPaul 1991; Fergusson & Horwood, 1992)

All the teacher ratings were moderately to highly correlated with each other, with the correlation between ratings of attention and concentration being particularly high. Concentration in reading and maths, defined as the ability to remain “on task and not be distracted” was designed as a measure of selective attention. Attention in reading and maths defined as the ability to “sustain attention and persevere” was designed as a measure of sustained attention. The correlations obtained suggest that teachers’ interpretation of these two constructs, as defined in this study, was practically synonymous. This could be because the teachers did not understand the intended difference between these two constructs. However definitions for each measure were provided in an Instruction Sheet for the teacher ratings by the researcher who pointed out to teachers the differences between the ratings. It is also possible that the difference between the concepts is not evident in classroom behaviour or that teachers have a more global conception of attention than the process used in this study was intended to measure.

Almost all of the correlations between teacher ratings of attention and children’s achievements in reading and numeracy were moderate. Teacher ratings of children’s interest and attention in maths were more related to children’s achievement in maths than their achievement in reading. Similarly reading performance is more related to interest and attention in reading than interest and attention in maths. However the differences between these correlations are all small suggesting that behavioural

aspects are predominately general across class topics, and only slightly affected by content area.

All of the teacher ratings were more strongly related to irregular word reading than they were to nonword reading. This is noteworthy given that irregular word reading may be more dependent on acquisition and teacher involvement than nonword reading. Irregular word reading is a measure of orthographic processing ability which is assumed to be dependent on print exposure and reading experience (Cunningham & Stanovich, 1990) whereas nonword reading is a measure of phonological recoding skills. Phonemic awareness, which may be involved in nonword reading, has been shown to be a very good longitudinal predictor of reading skills (Share, 1995) even in pre-school children who have usually had very limited exposure to formal teaching (Byrne & Fielding-Barnsley, 2000; Rack, Snowling & Olson, 1992).

Research suggests a reasonable level of accuracy for teacher's predictions of student achievement (Feinberg & Shaprio, 2003; Hoge & Coladarci 1989) but teacher ratings of attention are not necessarily independent of their perception of children's achievement. The moderate correlations found in this study between teacher ratings of children's attention and their achievement scores in reading and maths may have a number of explanations:

One explanation is that they may indeed be due to teachers' accurate judgments of children's ability to pay attention and a moderate relationship between this ability and children's achievement.

A second possibility is that those children who are lower in achievement may be less likely to invest attention in related class activities. If there is a relationship between attention, as perceived in classrooms, and achievement then it does not necessarily follow that good ability to pay attention is the cause of high achievement.



It is possible that poor achievement results in children failing to pay attention in class. Rowe and Rowe (1992b) for example, in a study of the relationship between inattentiveness in classrooms and reading achievement in a sample of 5,000 students aged 5 to 15, found that not only did inattentive behaviours in the classroom have strong negative influences on reading achievement but also that lower levels of reading achievement led to increases in inattentiveness.

Another possible explanation is that teachers' judgments may be influenced by their knowledge of children's achievement. Teachers may make the assumption that children who are good readers or good at maths must be paying attention in class. Cognitive tests of attention on the other hand are not influenced by teachers' perceptions of children's achievements. They may give a more independent measure of children's ability to pay attention but they may be influenced by other cognitive abilities such as processing speed which are related to achievement (Catts, Gillispie, Leonard, Kail & Miller, 2002).

A comparison of teacher ratings of children's attention and their results on the cognitive tests in this study shows a weak relationship between the measure of selective attention (SkySeRL), and teacher ratings of interest and attention in both reading and maths but the other cognitive measures of showed no significant relationship with the teacher ratings of attention. This could be an indication that the teacher ratings are not accurately measuring attention or it may be that the cognitive tests do not reliably assess the aspects of attention evident to teachers.

This study showed only a weak relationship between children's results on the cognitive tests of attention and their results on achievement measures. Although this study used only three subtests of the Test of Everyday Attention (TEA-Ch), which would not be as reliable as the full test, reported correlations in the Test Manual

between scores on all nine of its subtests and scores on the Reading, Spelling and Arithmetic scales of the Wide Range Achievement Test-Revised (Jastak & Wilkinson, 1984) for 160 children confirm that the correlations are all weak ones. After removing a measure of accuracy for Creature Counting, one of subtests in the attention/control switching factor which was strongly associated with arithmetic ability, the range of correlations for reading, spelling and arithmetic across all 9 subtests is 0.08 to 0.33. Commenting on these results the authors state that the efficiency of selective attention as measured by visual search paradigms does not show a strong relationship with academic achievement and that this is also true for most of the subtests in the attention control switching factor. They do, however, point to a significant relationship between sustained attention and academic achievement, stating that four of the five subtests that make up the sustained attention factor in their three factor model of attention “show significant correlations across each of the attainment measures” (Manly, Robertson & Nimmo-Smith, 1999) although these correlations range from .17 to .33 with a median correlation of only .19 for reading, .17 for spelling and .26 for arithmetic over all five subtests that make up this factor.

In the present study the relationships between the subtests used and the measures of academic achievement are not only weak, but they do not show the pattern reported by the TEA-Ch’s authors. In the study cited in the TEA-Ch Manual only sustained attention is shown as having a significant relationship with achievement measures. The results from the present study also show that sustained attention as measured by Score was associated with maths achievement (.30) and nonword reading (.23) although it had very little relationship with irregular word reading (.11). However the visual search paradigm Sky Search which showed very little relationship with any of the achievement measures in the study cited in the manual was associated with

irregular word reading (.34) and Opposite Worlds, the measure of attentional switching which also showed very little relationship with academic achievement in the study cited in the manual was weakly to moderately associated with all three attainment measures. The correlations for this subtest were .24 for nonword reading, .20 for irregular word reading and .28 for maths. The measure of suppressing the automatic response showed very little relationship to reading measures but had a stronger correlation (.31) with maths than Opposite Worlds.

These weak relationships between children's scores on the cognitive measures of attention and their scores on the achievement tests for maths and reading could indicate that the relationship between attention and achievement in reading and maths is a weak one although a stronger relationship has been found by other researchers using teacher and parent ratings (Merrell & Tymms 2001; Rabiner & Coie, 2000; Rabiner & Malone, 2004). The failure of the cognitive tests of attention to find such a relationship may therefore be a reflection of their poor construct validity.

Two measures of validity of the TEA-Ch are given in the Test's manual; the extent to which the separate factors of selective attention, sustained attention and attentional control show distinct patterns of performance in the normative sample and the relationship of the Test to other measures of attention

The TEA-Ch is a standardised and normed clinical battery of tests for children between the ages of 6 and 16, "that allows for relative assessment *across* different attentional capacities" (Manly, Robertson & Nimmo-Smith 1999). Each of the 9 subtests provides a partial loading on a model of attention made up of the three factors of selective attention, attentional control/switching, and sustained attention with the option of using the first four subtests as a brief screen of these attentional capacities. The normative sample used in the test is 293 children aged 6 to 16 which includes 54

children in the age bracket used in this study. Measures of inter-correlations between the subtests are shown in the manual only in the form of a Structural Equation Model of the three factors which suggests the assumed factors may be moderately related but that the individual subtests are only moderately loaded on the factors and thus individual subtests may be weakly related. This study used the first two of the measures from the brief screen, Sky Search, and Score to measure selective and sustained attention and the Opposite Worlds subtest, a measure of attentional control/switching, from the main battery. The cognitive measures of selective (SkySeRL) and sustained (Score) attention show very little relationship to each other but both of these measures are weakly but significantly correlated to the measure of attentional switching (Opposite Worlds).

The second measure of validity cited in the manual is the degree of convergence of its measures with other tests of attention. Ninety-six children from the normative sample were administered tasks thought to tap selective attention, (Stroop task; Trenerry, Crosson, deBoe & Leber, 1989 and Trails A Test; Spreen & Straus, 1991), the capacity to switch attention between two different sorts of target (Trails B Test; Spreen & Straus, 1991) and a test of impulsivity (Matching Familiar Figures Test; Arizmendi, Paulsen & Domino, 1981). The measures of selective attention were strongly correlated (.40 and .69) to Sky Search, the test used in the present study to measure selective attention. However the correlation for Opposite Worlds and Trails B, both of which are considered to be tests of attentional switching, was much weaker (.19). The tests of attention used were not considered to be measures of sustained attention so no direct comparison was made on this measure but the low correlations between measures of sustained attention, such as Score, and the other tests of attention is taken as further support of the factorial structure of the TEA-Ch.

Van Zomeren and Brouwer (1992) make the point that “there are no tests of attention ..... one can only assess a certain aspect of human behavior with special interest for its attentional component.” The effect of a task variable on performance tells us something about an aspect of attention but as the task is never assessing “attention” only, the other variables may obscure the role of the attentional component. Thus one may study children’s ability to count scoring sounds in a task that does little to grab their attention, stating that one is testing their ability to sustain attention. However a child in a quiet structured environment, one on one with the examiner, may perform well on this task but in other situations may not have a good ability to sustain attention. Some children may not display attentional difficulties on an individually administered test but these difficulties may be apparent in the more complex environment of the classroom. A further complication cited by van Zomeren and Brouwer is the fact that each test will inevitably tap several aspects of attention. For example visual search paradigms designed to measure selective attention will be ineffective if the child taking the test does not have the ability to sustain attention long enough to complete the task, particularly on timed tests such as Sky Search. Some of these difficulties are considered in the manual of the TEA-Ch which states that its subtests are not measures of attention. They are measures of auditory and visual detection, of counting, of response speed and so forth and the separable attention processes are inferred constructs believed to contribute significantly to differences in the efficiency of performance on these tasks. By simplifying instructions, using practice sessions, and reducing the contribution of perception, memory and reasoning the authors aim to minimise variability due to non-attentional factors.

One variable that significantly affects children’s scores on the Sky Search subtest, and which is not controlled for even in a structured testing environment, is the

search strategy that they adopt. Children who scan the row or columns of space-ships in an orderly fashion will often achieve the shortest time per target. Children who do not adopt a specific search strategy will tend to miss targets, will be less certain about when to stop searching and may continue checking after finding all the targets. Furthermore impulsive children may perform a quick, random and chaotic search which finds only a few targets. These children's time per target will be significantly less than a child who carefully but rather slowly searches through the targets despite the fact that the careful child has arguably better ability to sustain attention as well as better ability to selectively attend and resist distraction than the impulsive child.

In the manual of the TEA-Ch the authors suggest that for children with this kind of "unusual performance" it may be advisable to take into account how well children perform on Map Mission, the test's other measure of selective attention. This again suggests that individual subtests may be only moderately loaded on the factors in the three factor model of attention and that the validity, of individual measures at least, is not firmly established. It may be that the tests are reliant on non-attentional factors such as search strategy and a structured environment and this may account for the very low correlations between children's performance on these tests and teacher ratings of children's ability to pay attention in a classroom situation.

### *Conclusions*

This study did not find the sex differences in reading that have been reliably demonstrated. However, given the small effect sizes in large scale studies, this can be accounted for by the relatively small number of participants. It also failed to find sex differences in children's performance on the cognitive tests of attention and there were no significant sex differences in the teacher ratings of attention. Aside from the limited number of participants, it is possible that the consent process may have biased

against boys with perceived behavioural problems. However when discussing the relationship between children's scores on cognitive measures and children's abilities in arithmetic and reading this study supports the reported low correlations but not necessarily the specific patterns of previous studies cited in the manual of the TEA-Ch, although these studies do not have a large number of participants particularly when considering particular age ranges.

The results of this study give some support to the view that there is a relationship between children's ability to pay attention and their academic achievement, but they highlight the difficulties associated with measuring attention. Children's scores on the cognitive tests used in this study had only a weak relationship with their scores on measures of achievement in both reading and numeracy. Furthermore their scores on the cognitive tests of attention had only very low correlations with teacher ratings of their ability to pay attention in the classroom. Given the many methodological issues associated with measuring attention it is suggested that these low correlations may be partly due to the limitations of attempting to measure attention with cognitive tests that are administered in a quiet structured environment that places limited demands on a child's attentional capacity. Assessments of attention made by teachers in the classroom environment may be more valid, and this study found a moderate relationship between attention as measured by teachers and children's achievements in both reading and numeracy. However teacher's perceptions of children's ability to pay attention may be influenced by their perception of children's achievement.

This study highlights the need for valid and objective measures of attention that are less contaminated by cognitive performance or a perception of children's achievement and that capture what it is that teachers see when they assess a child's ability to pay attention in class. Research on different teacher ratings scales would be

useful to find which of these are effective in defining aspects of attention in a way that is meaningful to teachers. For example the method used to orientate teachers to the use of teacher ratings scales is an un-investigated factor influencing how teachers use these scales to rate children. Further research using behavioural observation of children in the classroom environment may also be useful in order to give a more objective assessment of children's ability to pay attention in a classroom environment. More effective and objective assessment of children's ability to pay attention using larger numbers of participants may show relationships between different aspects of attention and children's academic achievements and help to explain differences between boys' and girls' achievements in different subject areas.



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## Appendix A

### Irregular Word Test (Alexander, J.R.M., & Drinkwater, L.)

me, is, no, the, was, one, good, give, come, eye, wolf, work, head, friend, pretty, shoe, break, bowl, sugar, touch, answer, soul, island, blood, iron, sure, busy, stomach, ceiling, circuit, tongue, tow, chorus, lose, cough, sword, ton, routine, yacht, choir, champagne, drought, brooch, tomb, nought, foreign, distraught, plover, bouquet, sovereign, trough, depot, colonel, scythe, gauge, debris, meringue, pint, schism, beret, indict, regime, quay, benign, ninth, bough, righteous, heirloom.

A raw score of 68 is possible.

## Appendix B

## Teacher Ratings Form

"The Relationship between attention and achievement in reading and numeracy"

**IMPORTANT: Please read accompanying "Instruction Sheet for Teacher Ratings Form" before filling in this form**

**Date:**

[illegible]

All information will be treated in the strictest confidence

The code given in column two will be used for individual children. No child, teacher or school in the study will be identifiable. This study is being conducted by Mrs Gill Ta'eed ( telephone 62294535), a student in the School of Psychology, University of Tasmania.

## Appendix C

### Instruction Sheet for Teacher Ratings Form "The Relationship between attention and achievement in reading and numeracy"

The Teacher Ratings Form contains a number of items concerning children's abilities, motivation and behaviour in the classroom, set out as headings for ten columns. You are asked to give ratings for each child participating in the project. Please begin by filling in the names of each of the children in the first column. When this is done complete one item (i.e. one column) at a time for all the participating children and rate each of them from 1 to 7 **in comparison with the rest of the class** (i.e. do not just rate them in comparison to each other unless the whole class is participating). The notes below give a fuller indication of what we wish to measure. In an average class of 28 children the one to seven scale will equate to the following classifications:-

1	2	3	4	5	6	7
Lowest 4 in class	In lowest 8 in class	Little below average	Average	Little above average	In highest 8 in class	Top 4 in class

1. **Interest/motivation in reading** i.e. child's motivation to read, enthusiasm and keenness to take books home.  
(1 = no interest in reading, 7 = outstanding interest and enthusiasm)
2. **Interest/motivation in maths** i.e. child's motivation to engage in mathematical activities enthusiasm and keenness to complete maths' work sheets  
(1 = no interest in maths, 7 = outstanding interest and enthusiasm)
3. **Concentration in reading** i.e. ability to remain "on task" and not be distracted during reading  
(1 = very poor concentration, 7 = excellent ability to remain on task and focused)
4. **Concentration in maths** i.e. ability to remain "on task" and not be distracted during maths  
(1 = very poor concentration, 7 = excellent ability to remain on task and focused)
5. **Attention in reading** i.e. child's ability to sustain attention and persevere with a reading task  
(1 = very short attention span, 7 = very good ability to sustain attention)
6. **Attention in maths** i.e. child's ability to sustain attention and persevere with a task in maths  
(1 = very short attention span, 7 = very good ability to sustain attention)
7. **Co-operation with teacher** i.e. level of obedience and compliance with your instructions  
(1 = disobedient, defiant, 7 = cooperative, obedient, reliably follows instructions)
8. **Over activity** i.e. is the child always on the go? Finds it difficult to remain in his/her seat, is restless?  
(1 = very under active, passive, 7 = very active, always on the go)
9. **Ability to switch attention** i.e. does the child find it difficult to leave a task s/he is engaged in and concentrate on something else?  
(1 = finds it very difficult to switch attention, 7 = has no difficulty with switching attention)

Thank you for your time and co-operation in providing us with accurate information about the children participating in this study. All the information you have provided will be treated confidentially. No child, teacher or school in the study will be identifiable.

DATE: .....

INFORMATION SHEET (for parents/guardians)  
(On headed paper)

Invitation for your child to participate in a Research Project conducted by the School of Psychology at the University of Tasmania

*‘The relationship between attention and achievement in reading and numeracy.’*

Dear parent/guardian

Children in year three of ..... School are invited to participate in a research project conducted by the School of Psychology at the University of Tasmania during term 2, 2004. The project is being conducted as part of a Masters of Psychology degree by Mrs Gill Ta’eed (phone 6229 4535) who is being supervised by Mr James Alexander (phone 6226 2244), a Lecturer in the School of Psychology. The Southern Tasmania Social Sciences Human Research Ethics Committee and the Tasmanian Department of Education have approved the project. Details of this project are as follows:-

**Purpose of the Project**

Information collected will be used to help us understand more about how children learn reading and maths, the difference between the way girls and boys learn and how much their ability to pay attention in class affects the way they learn. A Consent Form is enclosed with this letter and an addressed postage-paid envelope is included to enable you to send it back to the school. Participation in this project is voluntary and your child can only participate if we receive a signed copy of this Consent Form from you.

**Children’s Participation**

Children will be asked to complete several assessments, similar to those sometimes conducted in schools by teachers. Sessions will be conducted on a one to one basis, in a quiet room in the school in a friendly and approachable manner. Each child will complete tests of reading, maths, attention, vocabulary and spatial ability (making designs or finding patterns). This will take about 45 minutes and will be completed in one or two sessions. No photographs or video will be taken. The project, tests or testing will not harm or disadvantage children, academically or emotionally. Children (and parents/guardians) are free to withdraw at any time and there will be no prejudice, academically or otherwise, that will ensue for children if they or their parents decide not to participate or elect to withdraw from participating after the start of the project.

**Class Teacher’s Participation**

Class teachers will also be asked to assist with this project by giving a rating of participating children on aspects of their ability to pay attention in class. This will be

confidential to the researchers, and parents should consult teachers if they wish to discuss their child.

### **Confidentiality**

All children, parents, teachers and schools who participate in this project will be assured of confidentiality and will not be named in publications or be identifiable in any way. A numbering system will be used for identifying children after the matching of parental consent, teachers' ratings and test scores are completed and only the researchers involved in the project will have access to the individual student's results. These will be stored at the University and shredded after 5 years. The findings that the researchers will write about when publishing their results will concern the pattern of group results and not individual children. The researchers will not be given any personal contact details for parents or children. We will receive all Consent Forms through the school.

Concerns of an ethical nature or complaints about the manner in which the project is conducted, can be discussed by contacting the Chair (A/Professor Gino Dal Pont ph 6226 2078) or the Executive Officer (Amanda McAully, ph 6226 2763) of the Southern Tasmania Social Sciences Human Research Ethics Committee.

### **Results**

The findings from the study can be presented at an information session at the school after the project is completed if requested by the school. They will also be included in a thesis for the researcher's Masters' degree course, may be published in an academic journal, and a summary of them will be available on the University of Tasmania website at [www.utas.edu.au](http://www.utas.edu.au).

Please feel free to contact us or to contact the school Principal if you have any questions about this project.

Yours sincerely,

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Mrs Gill Ta'eed (phone 6229 4535)

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Mr James Alexander (phone 6226 2244)

Note: If your child participates in this study you will be given copies of this information sheet and statement of informed consent to keep.

**CONSENT FORM: CHILDREN (completed by parent/guardian)**

*'The relationship between attention and achievement in reading and numeracy'*

1. I have read and understood the 'Information Sheet' for this study.
2. I understand that the study involves my child completing tests of reading, maths, attention, vocabulary and spatial ability (making designs or finding patterns) and that these tests will take place in two sessions each lasting about twenty minutes.
3. I understand that my child's class teachers will be asked to rate all participating children on aspects of attention and that this information is confidential to the researchers and I should consult with my child's teacher if I wish to discuss my child.
4. I understand that all research data will securely stored on the University of Tasmania premises for a period of 5 years and that the data will be destroyed at the end of 5 years.
5. Any questions that I have asked have been answered to my satisfaction.
6. I agree that research data gathered for the study may be published provided I or my child can not be identified as a participant.
7. I agree that my child may participate in this investigation and understand that she/he may withdraw at any time without any effect.

I.....(please write your name) give consent for my  
child .....(please write child's name) to participate in  
the research project described in the letter dated.....

I am / am not (*please circle*) interested in information about the project and its  
findings.

Signed .....

Date .....

Phone number .....

## Appendix E

### *Transforms to reduce skew*

There were three temporal measures, Sky Search, Same World, and Opposite World. Scatterplots against the results of the IrregularWord Test suggested they were somewhat skewed, and the relationship departed from bivariate normal, and this was improved by a log transform.

The general form of transform was chosen to reverse the direction so high scores corresponded to higher performance and to give convenient positive decimal representations (with approximate ranges of 2 to 10).

$$\text{TransformRL} = \text{Constant} - 10 * \log(\text{RawScore})$$

The constants chosen were 13 for Sky Search, 18 for Same World and 20 for Opposite World.

Table E1 shows the raw score medians, and the respective transforms applied to them.

Table E1

Measure	Median	Transform
Sky Search	4.4	6.6
Same World	27.0	3.7
OppositeWorld	33.7	4.7

As an index of interference SamOpWRL was calculated as the difference between the transformed scores for Same World and Opposite World.

$$\text{SamOpWRL} = \text{SameWRL} - \text{OppWRL}$$

This depends on the log of the ratio of the raw scores for Opposite World and Same World , noting that SameWRL and OppWRL involve negative logs it is a linear

function of  $\log(\text{Opposite World/Same World})$ , which is a reasonable index for an interference measure.